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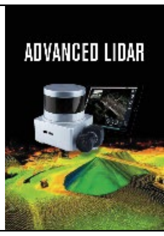

Advantages and Disadvantages of Laser Scanning with ViDoc Rtk Antenna: Ali Cafer Kümbeti

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Abstract

The first step in accurate and scientific documentation for the preservation of historical buildings is to measure them accurately with a minimum margin of error. Today, with the advancement of technology, laser scanning systems are widely used for this documentation process. With laser scanning, the dimensions, form and details of an architectural structure can be measured and recorded quickly and accurately. Laser scanning systems not only provide measurement data, but also allow the creation of three-dimensional models of these data, providing speed and convenience in the production of project drawings. The data obtained also provides access to wide audiences through the digital archive method in order to protect the structures and transfer them to future generations. IOS mobile laser scanning, a laser scanning technology developed in recent years, has made it possible to perform laser scanning in the documentation of historical buildings using the cameras of IOS devices with Lidar feature. However, since these devices use their own location services, they cause shifts in the images obtained from the scans and make it difficult to place the scans in the coordinate system. Since the use of this method alone does not provide accurate measurement data and increases the margin of error, it requires additional software. In this study, scans performed using the IOS device with the ViDOC RTK (Real Time Kinematics) Antenna were evaluated. Within the scope of the study, the measurement stages of Ali Cafer Kumbet, one of the important components of our cultural heritage, which was scanned using the ViDOC RTK antenna on the IOS device, were examined; the purposes for which the obtained data can be used were determined and their advantages and disadvantages were evaluated.

1. Introduction

Historical buildings are one of the most important representatives of the process in which cultures blend together, and they appear as the most obvious examples reflecting the lifestyles, development levels, beliefs, socio-demographic structures and construction styles of many different civilizations throughout the process. One of the main issues to be focused on is the preservation and transfer to the future of historical buildings which are the determinants of the urban identity and describe the authentic features of the cities that are changing rapidly due to globalization and are in danger of being similar to each other. The most important fact that forms the basis of conservation practices is to ensure the continuity of the building to be preserved without disturbing its original characteristics and in this context, documenting and defining historical buildings correctly constitutes the most important stage of the process.

Traditional methods and technology-supported modern measurement techniques are used for the documentation of historical buildings. Laser scanning systems, which are the subject of the study, are among the modern measurement techniques and allow measurements to be made with a low margin of error.

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Especially in recent years, digital documentation of cultural heritage has become an area of great importance for researchers. New technologies have facilitated not only professional documentation and scientific management and analysis of data, but also the creation of interactive user-friendly applications for educational and promotional purposes (Barrile et. al., 2019; Shih et. al., 2021). In this context, digital technologies have become an important tool for the promotion and preservation of cultural heritage to a wider audience.

With the development of technology, there have been major evolutionary changes in the techniques used for the collection of 3D data of cultural heritage (Vlachos et al., 2021). Methods that have been used for many years but have recently become popular include terrestrial laser scanning (TLS) and photogrammetry. However, technological innovations such as smartphones, tablets and low-cost sensors have made data collection easier and more affordable (Campi et al., 2021). The versatility, portability and ease use of such devices are the main factors that increase their professional or amateur use as 3D scanning tools. Also, technological advances related to built-in cameras and improved software have improved the quality of images captured with smartphones, thus increasing the quality of 3D models produced from these images (Ortiz et al., 2021). Since 2020, some applications have enabled the widespread use of these techniques by producing products with built-in LiDAR (Light Detection and Ranging) sensors designed specifically for VR and AR (Murtiyoso et al., 2021; Spreafico et al., 2021).

These devices, which contain LiDAR sensors, use their own systems as a location detection method. For this reason, there may be errors or shifts in the images obtained while performing measurements. This can be a serious problem for documentation studies. ViDoc RTK Antenna, which was produced to solve this problem, can be integrated into smart mobile devices with LiDAR sensors. In this way, scans are synchronized directly with PIX4Dcatch. Thus, since the antenna is connected to the NTRIP (Networked Transport of RTCM via Internet Protocol) service, it provides the opportunity to produce 3D models and georeferenced images with real-time RTK accuracy As a result of some studies, it has been seen that data with absolute accuracy less than 5 cm were obtained in the data obtained from the scans made with the ViDOC RTK Antenna. (Atay Engineering, 2023). Within the scope of the article, Ali Cafer Kumbet located in Kayseri Melikgazi District was scanned with the ViDOC RTK Antenna, and the advantages and disadvantages of the system were evaluated over the data obtained during and after the field study.

2. Method

2.1. Ali Cafer Kumbet

Located in a park in Kılıçarslan Neighborhood in the Melikgazi district of Kayseri, the kumbet, which is an important cultural heritage, was built using ashlar stone material on rubble stone filling. The octagonal body with a pyramidal cone was placed on a square-shaped funerary/ burial ground (Şahin, 2021) (Figure 1).

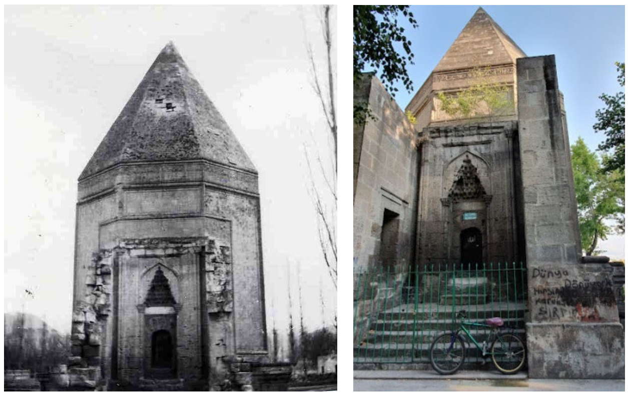

Figure 1. Ali Cafer Kumbet in its old and present state (VGMA, ASÜA, Personal Archive, 2022).

On the north facade are the iwan methal area and the crown gate of the kumbet, and there is a rectangular window on the methal walls (Figure 2). The square portico is accessed by stairs and the octagonal main hall is covered by a round dome. The facades are separated by borders and decorated with rectangular windows having pointed pediments.

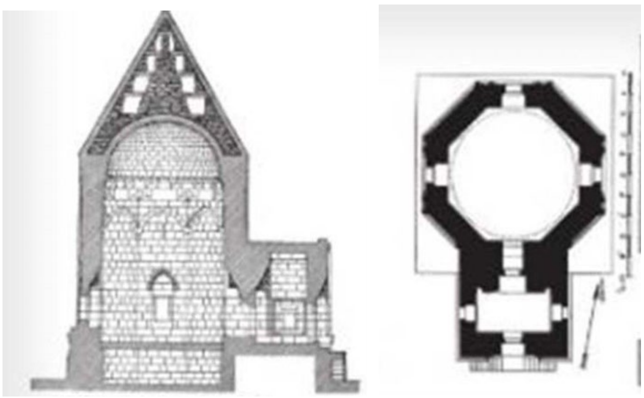

Figure 2. Section and floor plan of Ali Cafer Kumbet (Kayseri Cultural Inventory, 2015).

The building was registered as a monument with the Foundation Old Work Record Form created in the 1960s. At the time of the survey, it is stated that a large part of the portico section forming the entrance was demolished and can be identified by photographs (VGMA) (Figure 3).

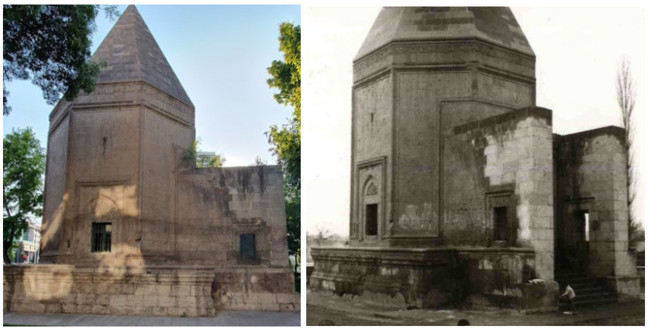

Figure 3. Ali Cafer Kumbet, old and present (VGMA, Personal Archive, 2022).

The exact construction date of the kumbet, which is one of the works that made Kayseri an important Seljuk city, is unknown due to the absence of any inscription on the building. Ali Cafer Kumbet, which is thought to have been built during the Eretnian period, is dated to the

XIVth century (Yanar, 2021; Gabriel, 1931). There is no source on Ali Cafer, to whom the construction and the name are attributed, and there are different opinions on the date of construction. Halil Edhem dates the construction of the kumbet to the Seljuk period, Tamara Talbot Rice to 1247-48, Mahmut Akok to the late XIII. century, Oktay Aslanapa and Ernst Diez to the middle of the XIV. century. (Diez & Aslanapa, 1955; Rice, 1961; Akok, 1970; Edhem, 1982).

2.2. Laser Scanning Studies with ViDoc RTK Antenna

The ViDoc RTK antenna is a real-time satellite data acquisition antenna that can be mounted on mobile smart devices equipped with LiDAR sensors. Synchronized with Pix4Dcatch, the antenna allows the production of RTK-accurate geo-referenced images and 3D models in real time while connected to any NTRIP service (URL A).

Designed by a German company, the viDoc RTK antenna is designed for maximum accuracy and works with Pix4Dcatch software for image acquisition. Handheld and compatible with smart devices, the viDoc RTK antenna is designed to replace expensive ground measurement equipment such as laser scanners to produce 3D final products (URL A). In order to facilitate the perception of a systematic approach to the product acquisition process, the following flowchart was created (Fig.4).

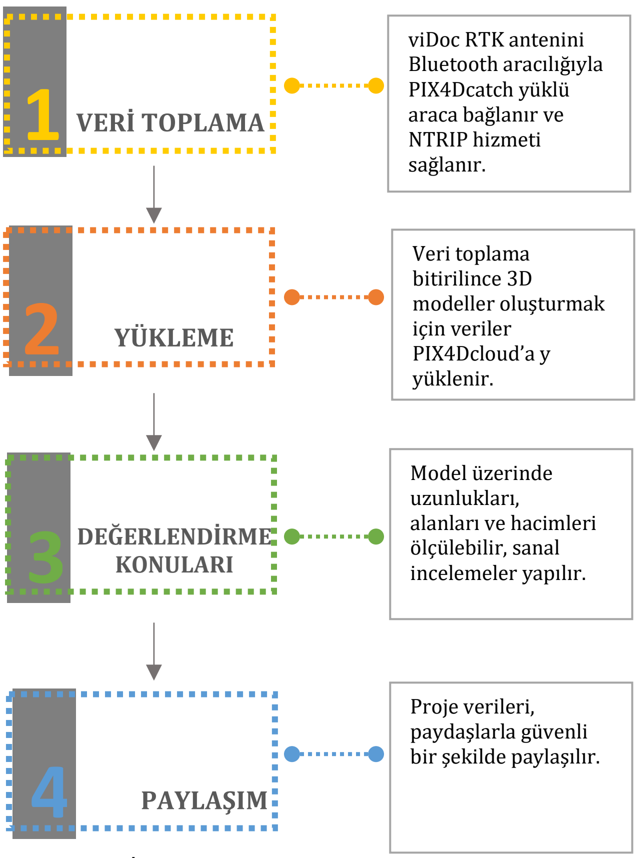

Figure 4. VİDOC RTK Antenna Flow Chart (modified from Atay Engineering).

In the data collection phase, which constitutes the first step according to the flowchart, the device to which the ViDOC RTK Antenna is mounted was connected to the satellite using RTK via PIX4Dcatch before starting the scan. Once it was determined that the connection was stable, the scanning process started (Figure 5).

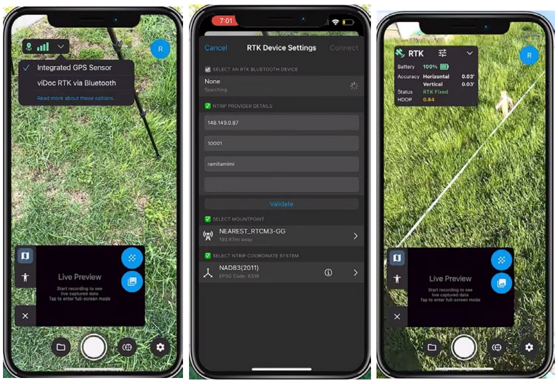

Figure 5. PIX4Dcatch configuration and interface.

Since the height of the building required scanning the building 3 times, the height of the building was divided into four levels and the areas between the determined levels were scanned in different steps. (Figure 6) In order not to cause data drift in the overlays obtained by overlaying the images, extra care was taken not to scan the same area twice or more while scanning.

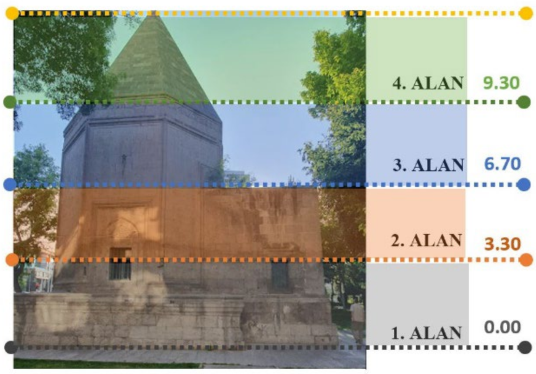

Figure 6. Levels and areas identified for scanning.

For the outdoor scanning, firstly, the device was held at eye level and rotated around the building to scan the 1st area between 0.00 and 3.30 elevations. At the second stage, the device was elevated on a carrying bar and a full-round scan was done. At this stage, the 2nd area between the elevations 3.30 and 6.70 was scanned. Finally, the transport bar was opened all the way and the 3rd area between 6.70 and 9.30 elevations, which are the highest points that can be taken by scanning, was scanned. The fourth area could not be accessed and the areas above the 9.30 level could not be surveyed. After the outdoor measurements were completed, the carrying bar was removed and the indoor measurements were started. During the measurements of the interior, due to the plan scheme of the building and lighting problems, the carrying rod could not be used, and therefore data could only be obtained up to 6.70 level in the interior. During the dome and interior scans, the device was kept as stable as possible and vibration was tried to be avoided, but some minor vibrations occurred in the scan data due to external environmental conditions and the potential for deflection of the carrying bar (Figure 7).

Figure 7. Photographs of the scanning process of the outdoor and indoor spaces of Ali Cafer Kumbet (Personal Archive, 2022).

3. Results

The data obtained as a result of the scan was processed using the PIX4Dcatch application. In addition to the Ali Cafer Kümbeti, which is the focus of the scan, there are also different objects in the surrounding texture (Figure 8). Due to the fact that the environmental data obtained in the scan overloaded the system, this point cloud data was purged by deleting unnecessary points in the PIX4Dcatch application (Figure 9).

Figure 8. Unpurged version of the Ali Cafer Kumbet point cloud data (North facade).

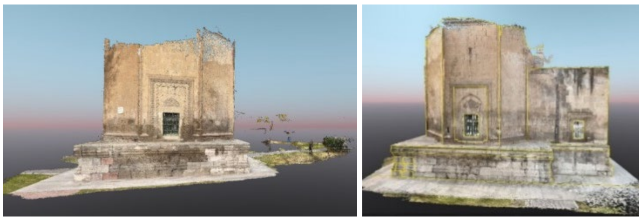

Figure 9. Unpurged and purged Ali Cafer Kumbet point cloud data (East facade).

The obtained data was reduced to a point cloud data consisting of 19666554 points after the cleaning process. The data can be processed in many different applications. However, despite the cleaning process, the data size is still very large, which caused freezes and slowdowns on the computer used when opening the data in various applications. Autodesk Recap Pro and CloudCompare programs were preferred because they are fast and easy to work with and to perform checks and examinations. With the Recap program, not only RGB view of the point cloud data can be obtained, but also views such as "elevation, normal" can be obtained. The Elevation view allows the elevations of the 3D data obtained from the scan to be observed in different colors. This can facilitate data control. The normal view allows a more detailed examination of the surface of the scanned data. These views can be used as support underlays that can facilitate and guide the drawing while performing survey drawings over the point cloud data (Figure 10).

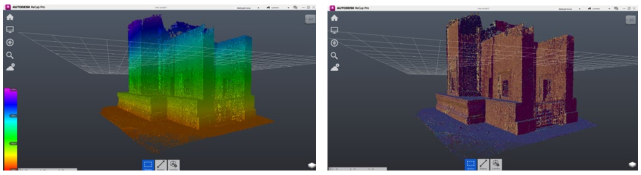

Figure 10. Elevation and normal views obtained from the Recap program

Instead of obtaining a .jpeg underlay over the obtained point cloud data, the point cloud can be imported directly into the Autocad program. In this way, the workload can be reduced while performing the drawings. The point cloud data obtained to create a underlay for the drawings was imported into the Autocad program with the "Insert-Attach" command. After positioning the imported point cloud data, the transformation options were locked so that it would not move during drawing. Then, the "section-two point" command was selected to create section underlays and section points were determined (Figure 11). The same process was repeated for the plan underlays (Figure 12).

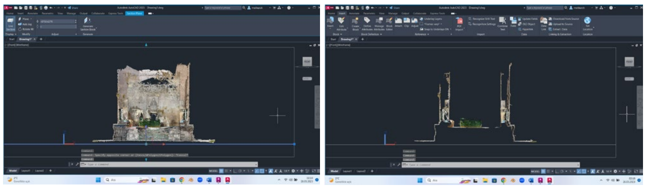

Figure 11. Creation of section underlays by using Autocad program.

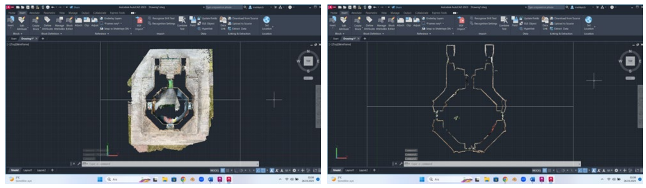

Figure 12. Creation of plan underlays by using Autocad program.

4. Discussion and Conclusion

Within the scope of the study, the Ali Cafer Kumbeti located in the Melikgazi district of Kayseri was scanned with the ViDoc RTK Antenna, an alternative LiDAR scanning method. The ViDOC RTK Antenna, which is integrated into IOS devices with LiDAR capability, aims to produce 3D models with an absolute accuracy of less than 5cm by providing high-precision position detection.

ViDOC RTK Antenna, which can be used instead of laser scanners that provide absolute location service, can be used at low cost as it can be integrated into phones and tablets. The high resolution of the cameras of the phones and tablets that can be integrated with the ViDOC RTK Antenna increases the quality of the product after scanning. At the same time, the PIX4Dcatch application, where data is transferred and processed, offers a simple workflow to the user. In this way, transactions can be solved faster and easier than alternatives. It can also perform long scanning operations thanks to the lithium batteries inside. Since the method is mobile, it provides opportunities such as portability and fast assembly. Thanks to these opportunities, working time in the field is shortened.

In addition to its many advantages, this scanning system also has some disadvantages. The entire height of the Ali Cafer Kumbet could not be obtained by scanning. Due to the possibilities provided by the carrying stick, a maximum height of 9 meters could be scanned. Since this scanning stick has a thin and long structure, the carrying stick may deflect during measurement. At the same time, the lack of optimization of the data obtained makes it difficult to process the data and transfer it to the 3D model as a mesh surface. High performance computers are needed for this. During the scanning, carrying the device in mobile for a long time tires the person that performing the scan. For this reason, after a certain period of time, there may be shifts in the images obtained in the scan because the device cannot be kept stable.

Table 1. Advantages and disadvantages of scanning with the ViDOC RTK Antenna

Advantages	Disadvantages
It offers scanning at low cost.	In cases where the height of the building is too high, scanning cannot be performed.
The PIX4Dcatch application offers a simple workflow.	The large number of points makes it difficult to process data and work on the mesh surface.
Features such as ease of transportation and fast assembly shorten the working time in the field.	Holding the device steadily in the hand during scanning makes the scanning process difficult.
Lithium batteries enable long scanning operations.	For a good result, the person performing the screening should be experienced and skilled.
Provides absolute position accuracy below 5cm.	

As a result, it was observed that laser scanning with the ViDOC RTK antenna is an efficient system for small-scale structures due to its low cost and mobility, its simple workflow, its ability to perform long scans with lithium batteries, and its absolute position accuracy below 5 cm. However, it has been determined that it can be efficient in medium-scale buildings with the support of equipment such as aerial LiDAR, while it may be inefficient in large-scale buildings.

The advantages and disadvantages of scanning with the ViDOC RTK antenna are given in Table 1 (Table 1). In order to minimize these disadvantages, it is very important to examine the structure or area to be scanned in advance and determine the most effective methods. For example, if structures and groups of structures with high building heights such as the Ali Cafer Kümbet are to be scanned, aerial laser scanning methods should be used in addition to the ViDOC RTK antenna. In order to overcome another disadvantage, which is the high number of points, detailed point cloud cleaning should be performed through the PIX4Dcatch application. At the same time, the use of high-performance computers will facilitate post-scan data processing.

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Author contributions

The authors declare that they have contributed equally to the article.

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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